Canadian Census of Marine Life

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Focus on support of Ecosystem Approach to Management (EAM)

- What is EAM? Maritimes experience
- Research agenda
  - Community level
  - Species level
  - Population / Genetics level
- Causality challenges

What is EAM?

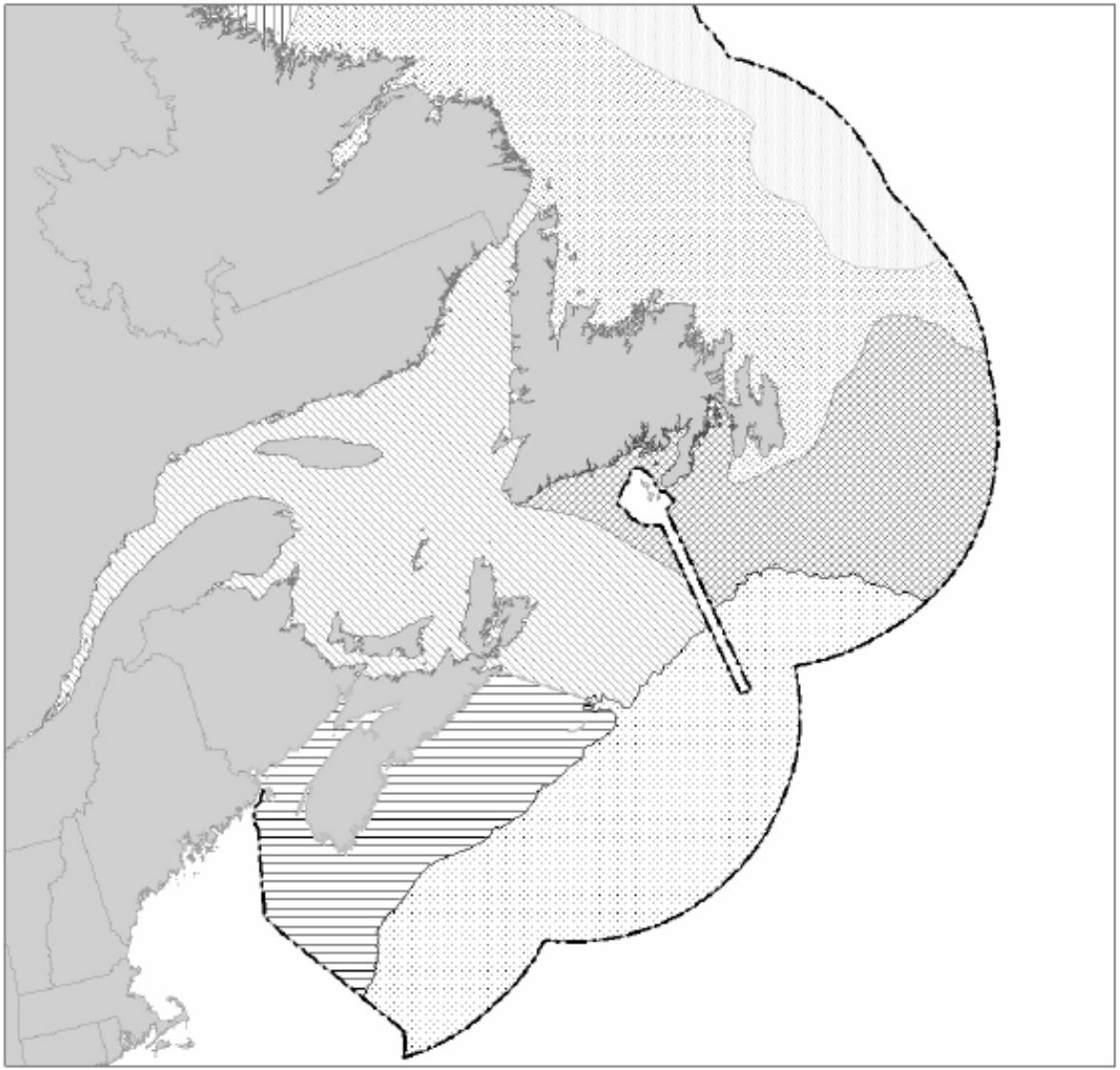
- Two Areas of Experience
  - Eastern Scotian Shelf & Gulf of Maine

- Challenges
  - Diverse perspectives of basic concepts
    - Tension between pragmatism & elegance
  - National policy evolving during implementation efforts

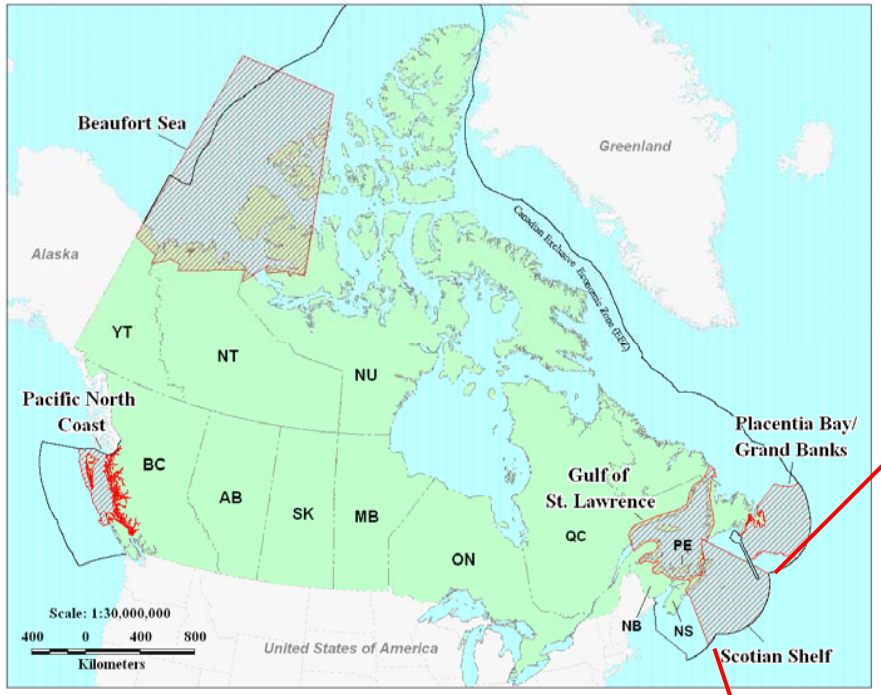
Management Area for EAM

- Biodiversity considered across wide range of spatial scales
- Many existing administrative areas for fisheries & other ocean uses
- Challenge
  - Relative importance of ecological patterns versus administrative convenience

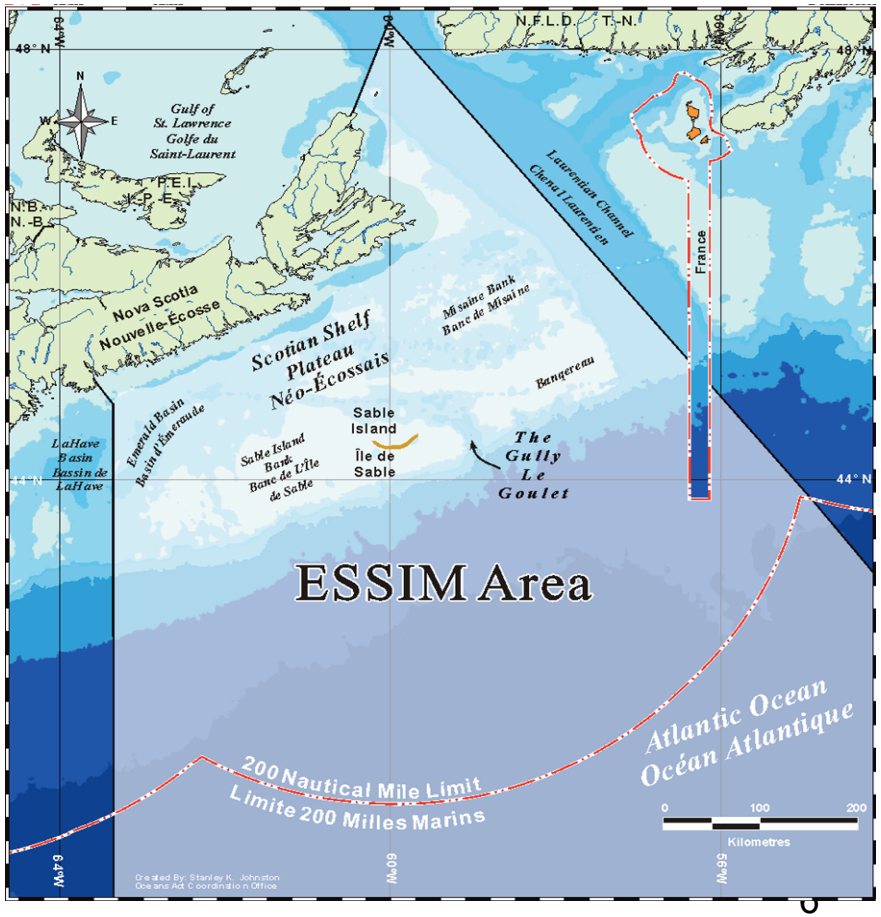
Atlantic Ecoregions



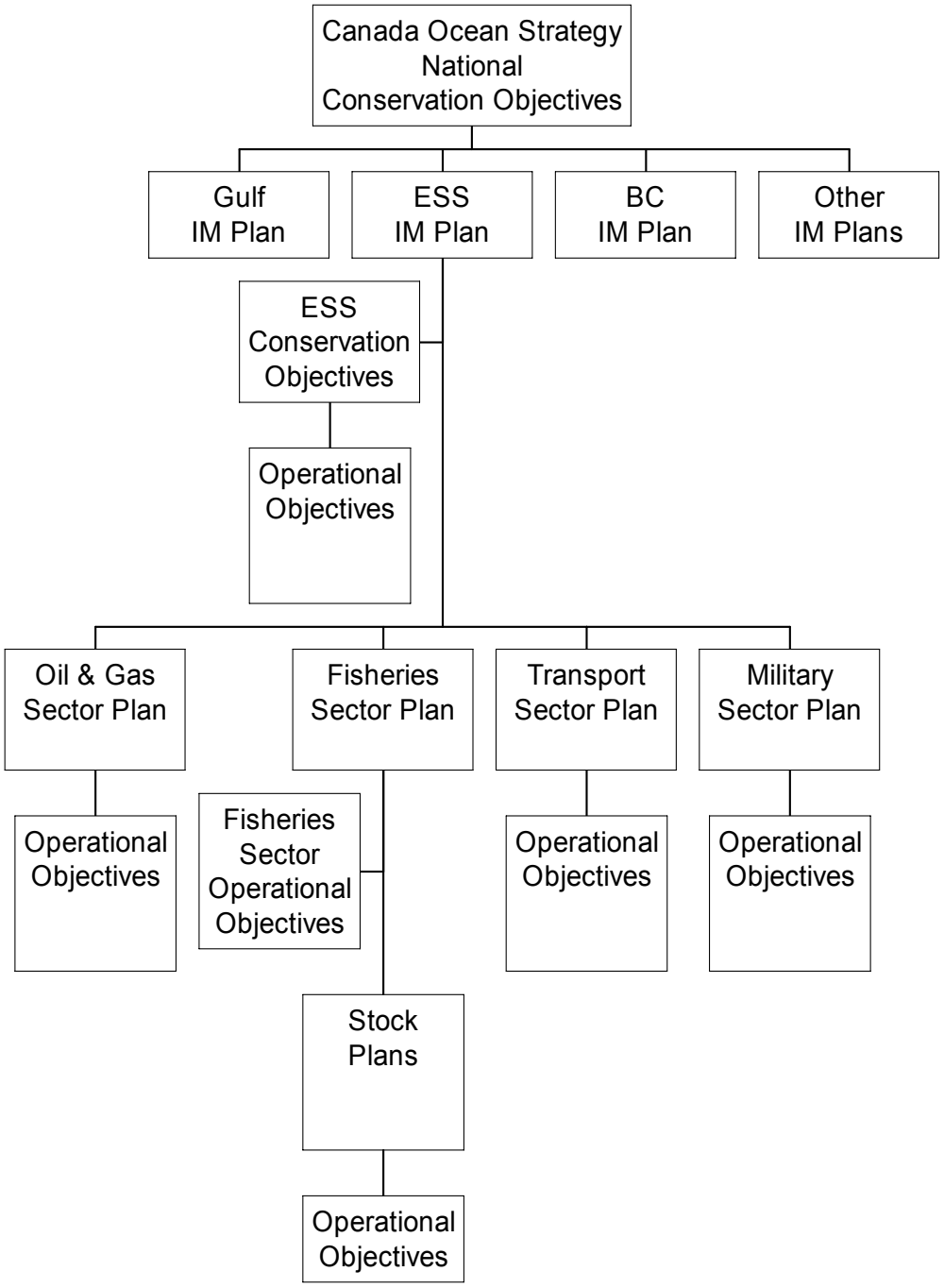
Eastern Scotian Shelf Integrated Management Planning Area



Ongoing Dialogue on ESSIM / GOMA Boundary



Planning Process for Conservation Objectives of EAM



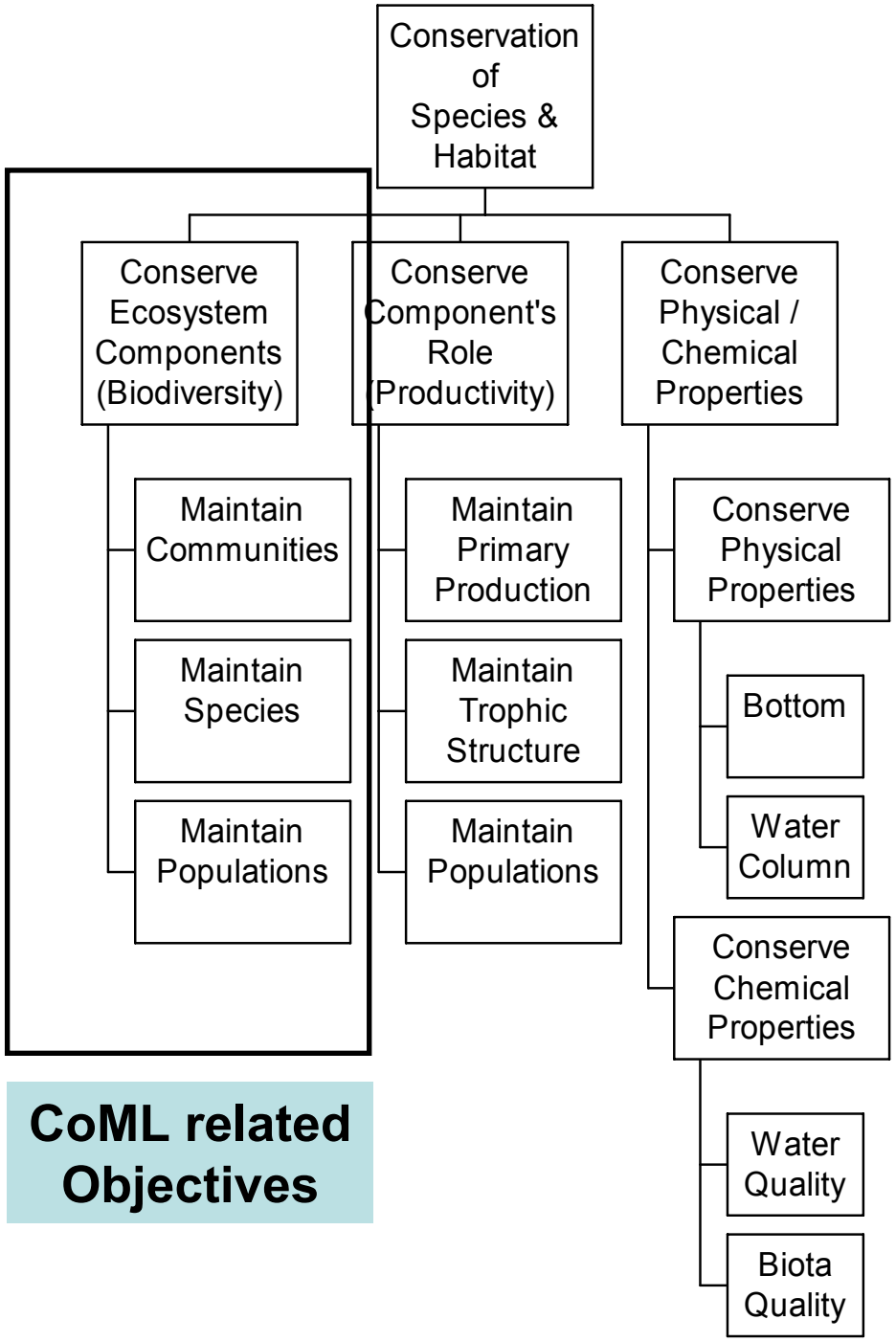
IM Plan Hierarchical Structure

National
Conservation Objectives
(Conceptual)

IM Area Level
Conservation Objectives
(Conceptual)
Operational Objectives
(Ecosystem Health)

Sector Level
Operational Objectives

SubSector Level
Operational Objectives



Overarching Conservation Objectives

GB and ESS Conservation Objectives developed consistent with this framework

Steps to Operationalize IM Plan

1. Identify Conservation Issues & Ecosystem Components & state IM Plan Conservation Objectives using national framework as guide

2. Determine Appropriate Ocean Sectors to implement IM Plan Conservation Objectives

3. Define Operational Objectives for IM Plan Area (cumulative impacts)

4. Define Operational Objectives for each Ocean Sector

Identification of Issues & Ecosystem Components in IM Area (step #1)

- Determine IM Area specific Issues
- Many possible ways to do
  - Scientific community review
  - Stakeholder consultations

  } **CoML input**
- Result is Layman's understanding of Issues at IM Area Level
- Sort these by National Objectives
- Identify Ecosystem Components associated with each Issue

Identification of Issues & 'Ecosystem Components' in IM Area

National Conservation Objective	Fisheries	Oil & Gas	Transport	Military	Other Stakeholders (NGOs & Public)	Specific Ecosystem Components on ESS related to the Issues
Maintain communities	Modification of Bottom habitat	Effects on Benthic Biota		Impact of Explosives on Bottom Diversity	Protection of Fragile Benthic Communities I.e. Coral and in Gully	Diversity of the benthic community, the coral community and the high diversity benthic community in the Gully
Maintain species	Protection of Species at Risk, low productivity & narrow niche species	Drilling Waste and Noise (seismic & acoustic) Effects on marine mammals & sea turtles	Impact of Shipping Noise on Marine Mammals, Ship/whale collisions, Introduction of Invasive Species through Ballast water	Impact of Noise on Marine life	Protection of Northern Bottlenose Whale & Leatherback Turtles & other Species at Risk	Overall Species Diversity & specifically the status of species designated Endangered or Threatened
Maintain populations	Maintenance of Population Richness within Management units					Genetic Diversity of populations under Human Pressure
Maintain primary production		Impact of Produced Water Discharges on Primary Productivity	Impact of pollution on Primary Productivity			Productivity of Base of Food Chain
Maintain trophic structure	Harvesting of forage species				Harvesting of Krill	Productiviity of Each Trophic Level (incl. Forage species) and Energy Transfer along Food Chain
Maintain mean generation times of populations	Fishing Mortality on directed & by-catch species	Drilling Waste and Noise (seismic & acoustic) Effects on fish larvae, fish and shellfish	Impact of oily discharges on Seabirds			Growth & Recruitment Productivity of Individual Populations
Conserve ecosystem's physical features - critical bottomscape		Drilling muds disposal and contaminant degradation				Sediment Quality
Conserve ecosystem's physical features - water column properties	Fishing Noise Impacts on Ecosystem	Seismic Impacts on Ecosystem	Shipping Noise Impacts on Ecosystem	Miltary Noise Impacts on Ecosystem		Overall Sound Environment
Conserve ecosystem's chemical features - water quality	Ship-source Pollution	Produced Water Discharge, Contaminant Biodegradation & Biotransformation	Oil Pollution	Ship-Source Pollution		Overall Chemical Environment
Conserve ecosystem's chemical features - biota quality		Bioaccumulation	Biocontamination			Physiological Processes of Biota

Ecosystem Objectives for IM Area (step #1, biodiversity example)

A. Conservation Objectives Related to Biodiversity

National Conservation Objective	Ecosystem Component	Conservation Objective (in increasing order of specificity)

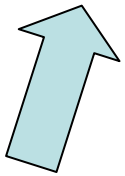
Maintain communities within bounds of natural variability	Diversity of Benthic Communities	• Protect Benthic Communities susceptible to disturbance
		  • Prevent significant adverse alteration of each benthic community
		  • Maintain area of disturbance within identified limits

	Diversity of Fragile Coral Community	• Protect Fragile Benthic Communities • Prevent significant adverse alteration of Coral Communities in Stone Fence area
	High Diversity Benthic Community in Gully	• Protect High Diversity Benthic Communities • Prevent significant adverse alteration of Benthic Communities in the Gully
Maintain species within bounds of natural variability	Overall Species Diversity	• Protect Natural Communities from Invasive Introductions • Prevent significant adverse introduction of exotic species

		• Maintain Continued Existence of all Species
		  • Minimize impact of human activity on non-target species
		  • Minimize incidental mortality

	Status of Species at Risk	• Restore Abundance of Species at Risk • Manage recovery of SAR (e.g. Cod, Bottlenose Whale, Leatherback, Cusk & Harbour Porpoise)

Maintain populations within bounds of natural variability	Genetic Diversity of populations under human pressure	• Maintain meta-population structures
		  • Maintain Components of Populations impacted by human activity
		  • Prevent elimination of spawning/breeding component by human activity



Driven by issues specific to IM Area

Sectors Responsible for Implementation

Ecosystem Components on ESS related to the Issues	IM Plan (Ecosystem Health)	Air Pollution from NE US	Water Pollution from GSTL	Fisheries Sector	Stock Fishing Plans	Oil & Gas Sector	Transportation Sector	Defense Sector
Diversity of Benthic Community	X			X	X	X		
Diversity of Fragile Coral Community	X				X	X		X
High Diversity Benthic Community in Gully	X				X	X		X
Overall Species Diversity	X				X		X	
Status of Species at Risk	X				X		X	
Genetic Diversity of Populations under Human Pressure	X				X			
Productivity at Base of Foodchain	X	X	X					
Productivity of Forage Species	X			X				
Productivity of Each Trophic Level	X							
Energy Transfer along Food Chain	X			X				
Growth Productivity	X				X			
Recruitment Productivity	X				X			
Sediment Quality	X					X		
Sound Environment	X					X		X
Chemical Environment	X		X			X		

Area Operational Objectives (step #3)

Productivity	
Primary Productivity	• *Control alteration of **vital nutrient concentrations** affecting primary production at the base of the food chain by algae*
Community Productivity	• *Manage **trophic level removals** taking into account consumption requirements of higher trophic levels* • *Manage **total removals** taking into account system production capacity*
Population Productivity	• Keep **fishing mortality** moderate • Allow sufficient **spawning biomass** to escape exploitation • Promote positive **biomass change** when biomass is low • Target **% size/age/sex** of capture to avoid wastage • Limit disturbing **activity in spawning areas/seasons** • Manage **discarded catch** for all harvested* species
Biodiversity	
Species Diversity	• *Control incidental **bycatch or mortality** for all non-harvested* species* • *Minimize **change in distribution** of invasive species*
Population Diversity	• Distribute population **component mortality in relation to component biomass**
Habitat	
	• *Manage **area disturbed** of bottom habitat types* • *Limit **amounts of contaminants, toxins and waste** introduced in habitat* • Minimize **amount of lost gear** • *Control **noise or light level/frequency***

CoML related Objectives

Indicator

Preliminary Evaluation of Georges Bank FMPs (step #4, example)

		GF	HF	SF	L/CF
Productivity					
Primary	Limit alteration of ***essential nutrient concentrations*** affecting primary production				
Community	Limit ***trophic level catch biomass*** with respect to trophic demands of higher levels				
	Limit ***total catch biomass*** within system production capacity				
Population	Keep ***fishing mortality*** moderate				
	Permit sufficient ***spawning biomass*** to evade exploitation				
	Promote positive ***biomass change*** when biomass is low				
	Manage ***% size/age/sex*** of capture				
	Prevent disturbing ***activity in spawning areas/seasons***				
	Manage ***discarded catch***				
Biodiversity					
Biotope/seascape	Limit ***% area disturbed*** of seascape/biotope types				
Species	Limit incidental ***bycatch or mortality***				
	Minimize ***change in distribution*** of invasive species				
Population	Distribute population ***component catch as a % of component biomass***				
Habitat					
Bottom	Limit ***% area disturbed*** of habitat types				
Water Column	Limit ***amounts of contaminants, toxins and waste*** introduced in habitat				
	Minimize ***amount of lost of gear***				
	Control ***noise level/frequency*** with respect to species of risk				

- Blue: high relevance that currently receive attention
- Red: high relevance & require attention
- Others: of low relevance

Current Compliance with EAM

- Most attention presently given to managing exploitation of commercial resources

- Emerging priorities
  - Managing discards and incidental mortality of non-target species
  - Limiting disturbance of benthic habitat

<u>CoML research reflects these priorities</u>

CoML Research Agenda

Biodiversity Research

At

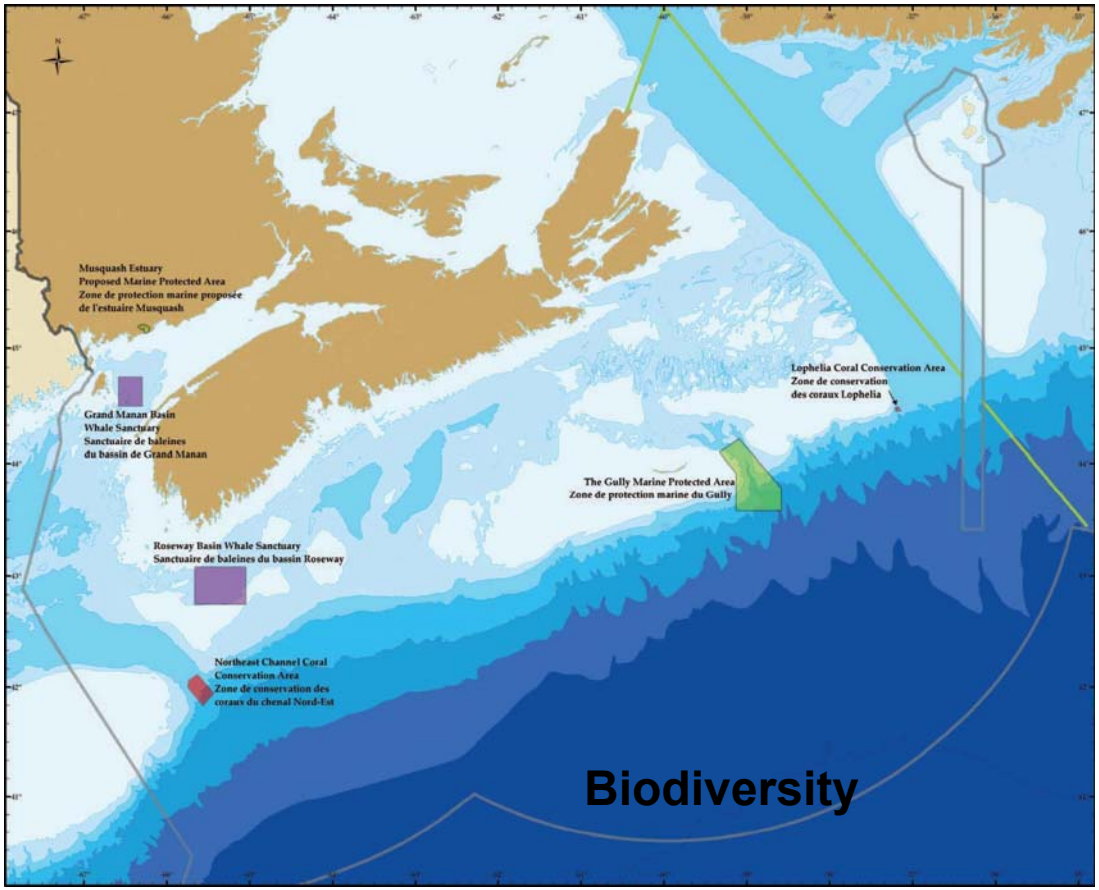
Community/Seascape Level

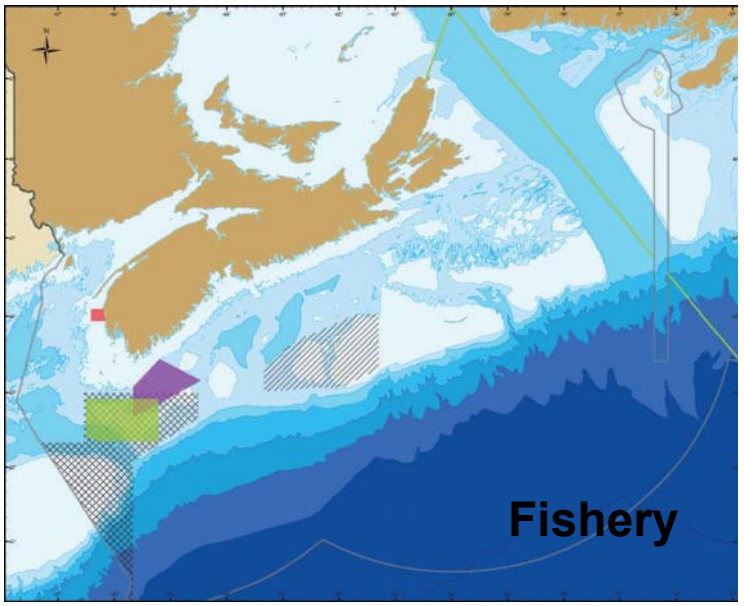
Are current fishery closures & gear restrictions adequate to protect benthic habitat?

- Can benthic community spatial patterns be predicted from geological, oceanographic & biological observations?

- What proportion of each benthic habitat type needs to be protected?
  - Sensitivity of benthic communities

What is relationship between size & location of protected areas & benthic community conservation?





Current Closures

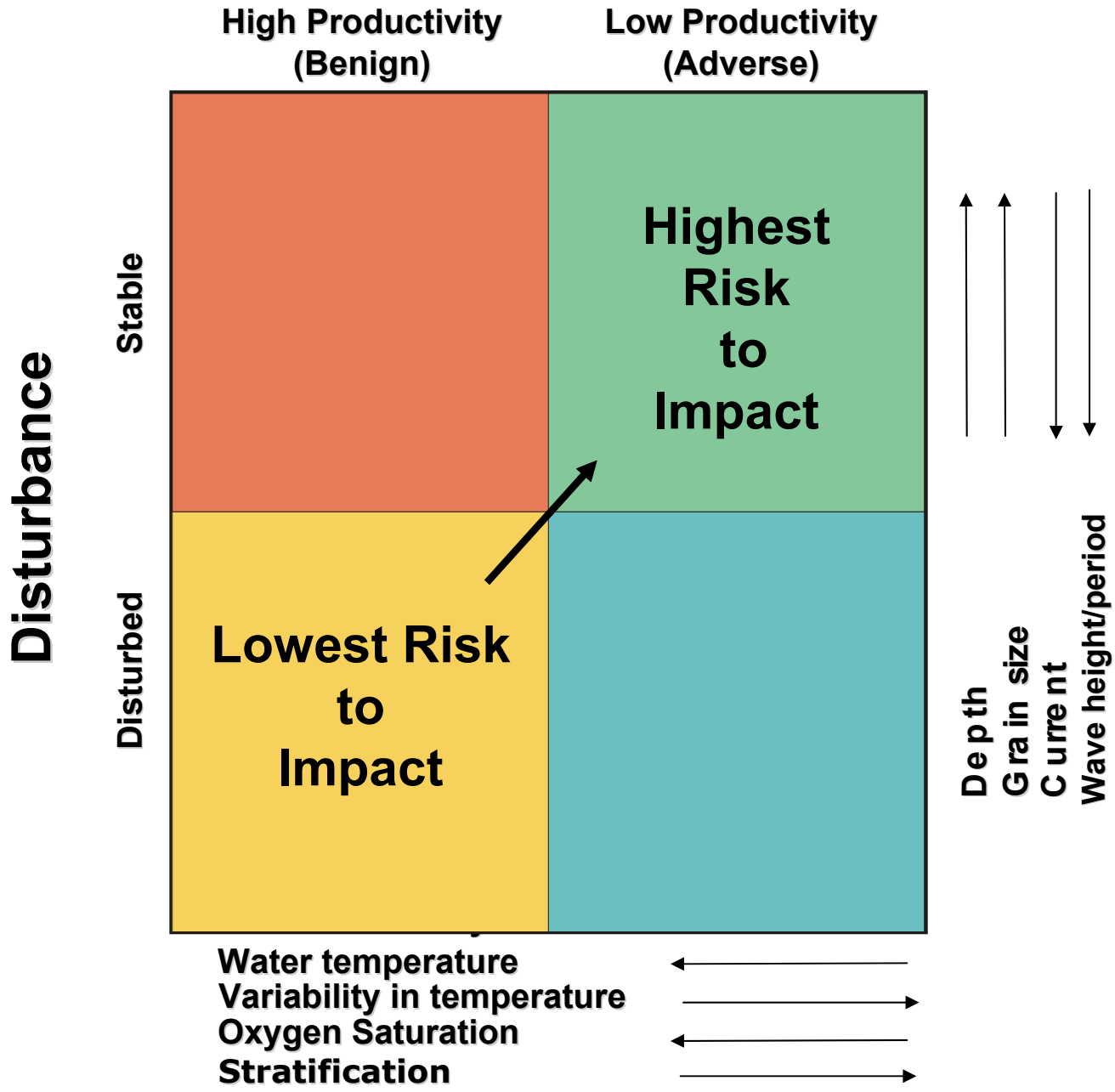
Community/Seascape Biodiversity

Modelling Approach

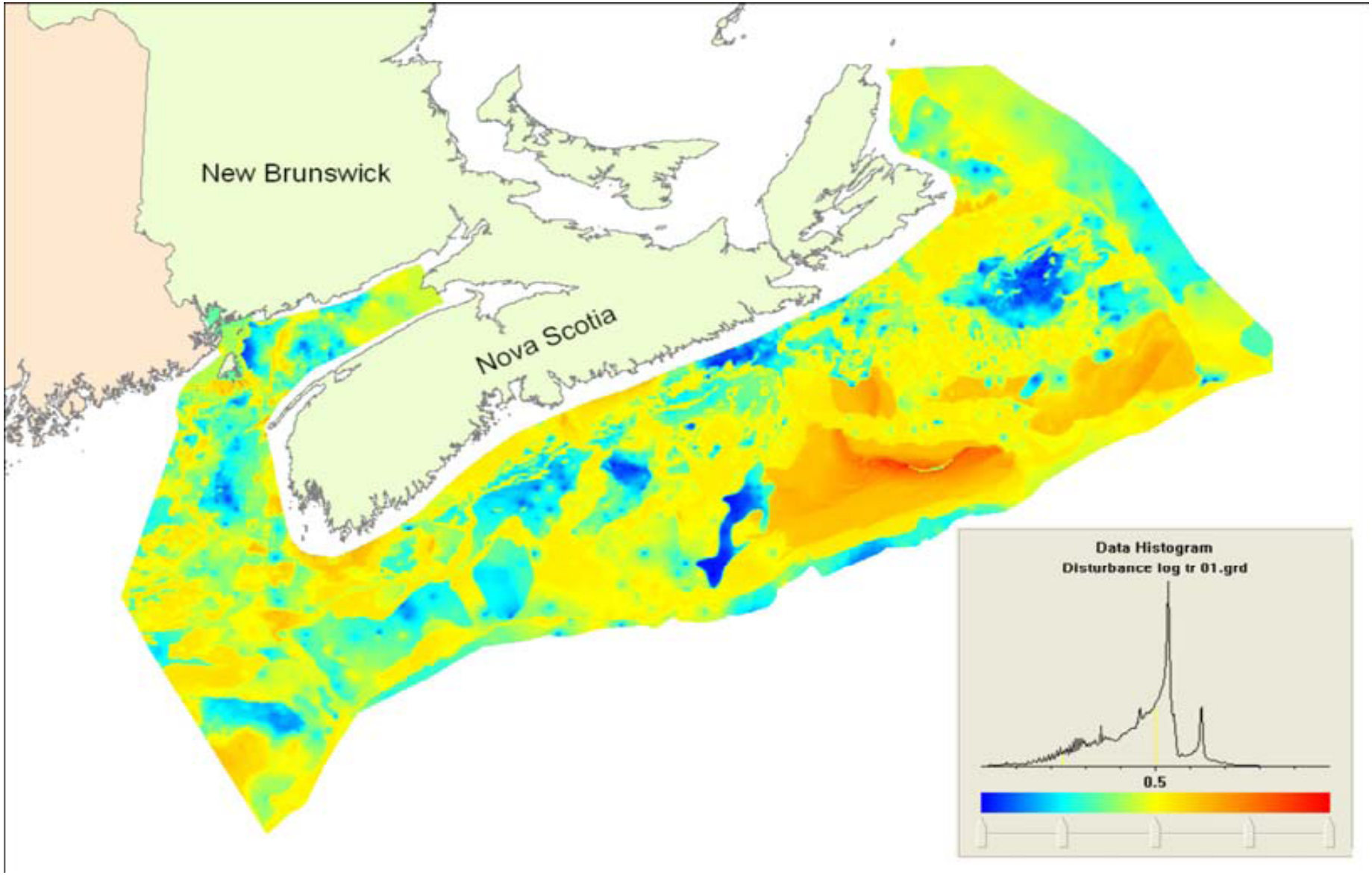
Expected Life History Traits according to Southwood Model

	Physiologically Benign (High Productivity)	**Physiologically Adverse (Low Productivity)**
Physically Stable	Offspring medium & small Longevity medium	Offspring few & large Longevity long
Physically Disturbed	Offspring many small Longevity short	Offspring medium large Longevity medium

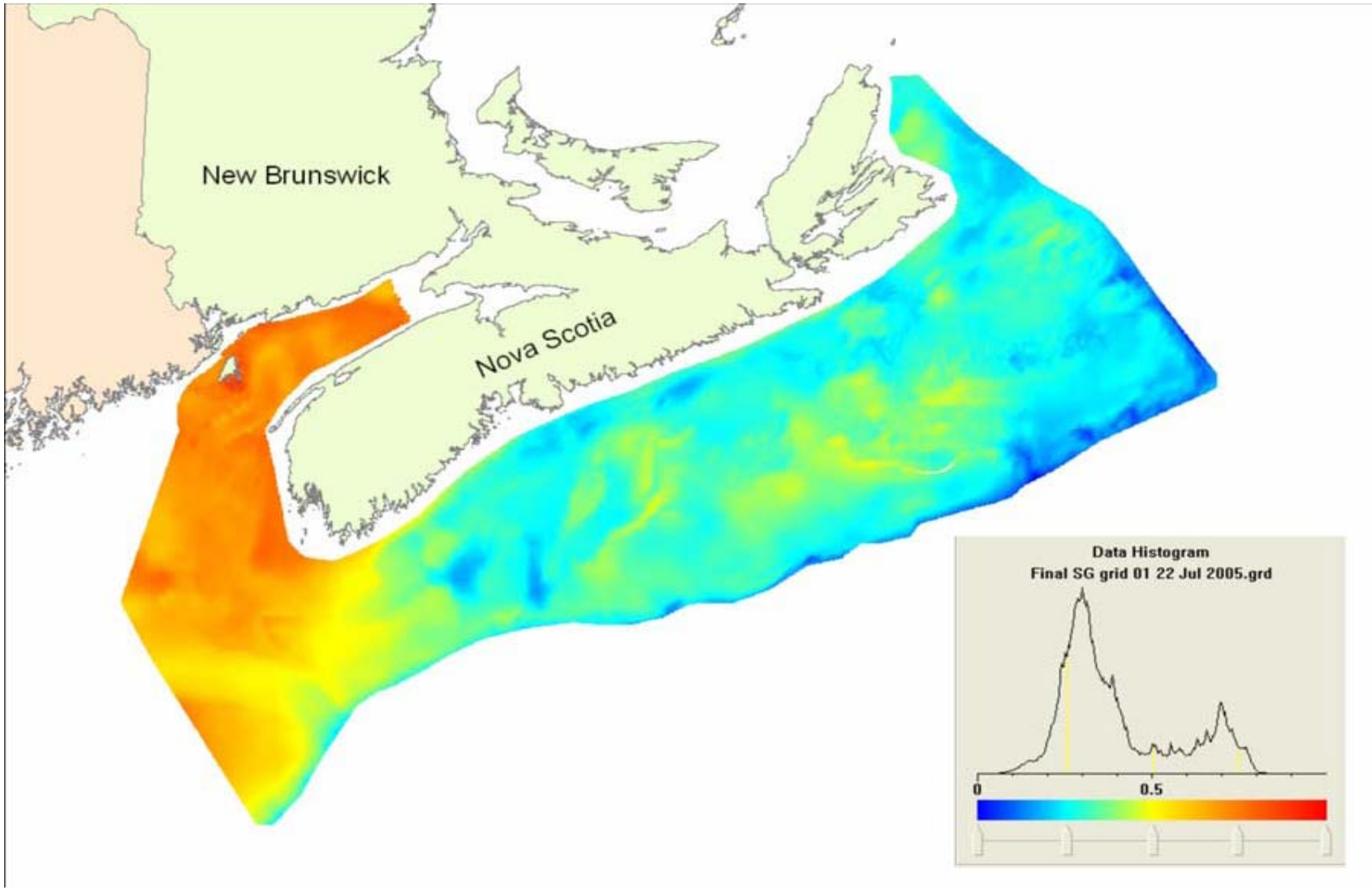
Scope for Growth



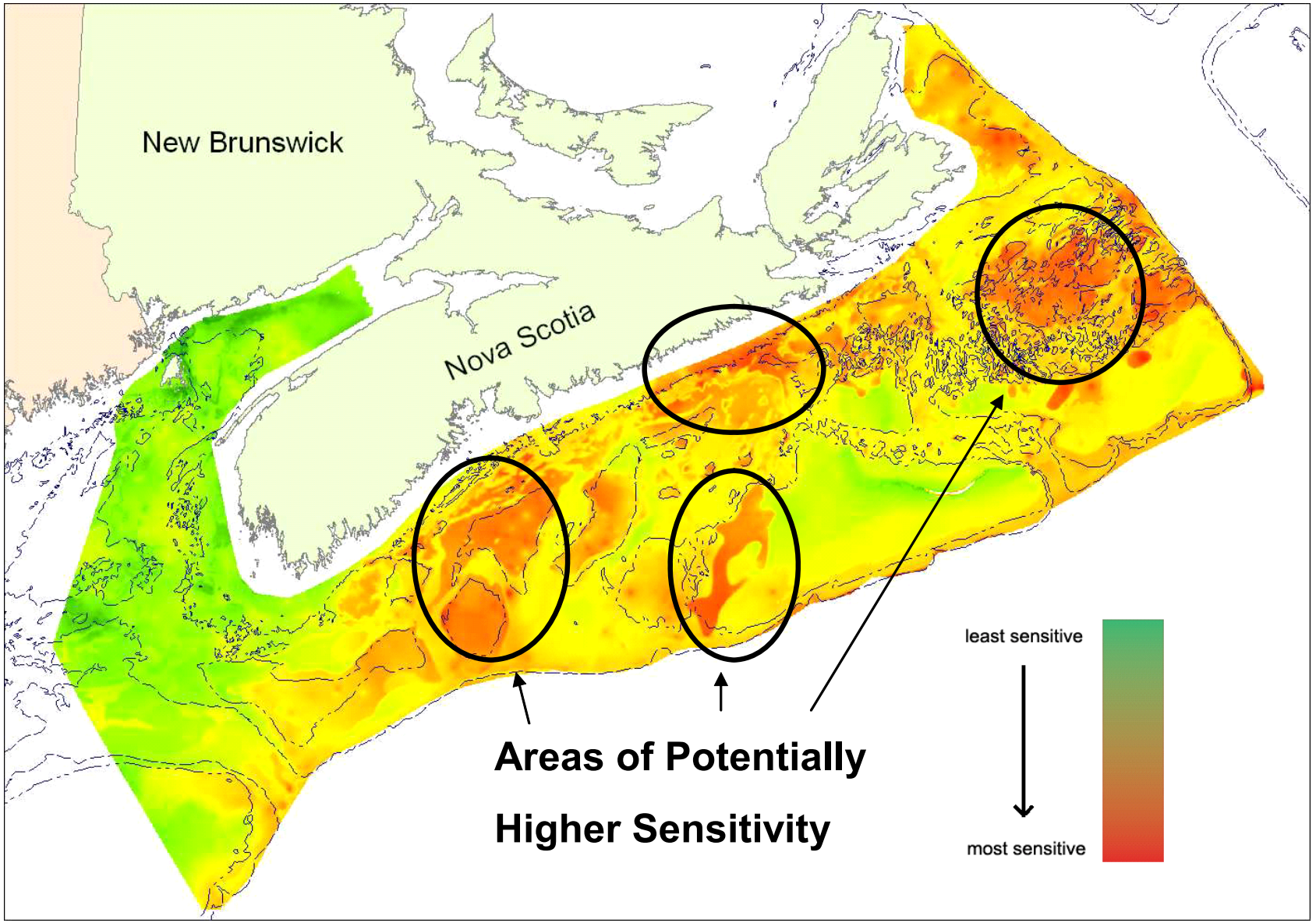
Disturbance



Scope for Growth



Sensitivity of Benthic Communities

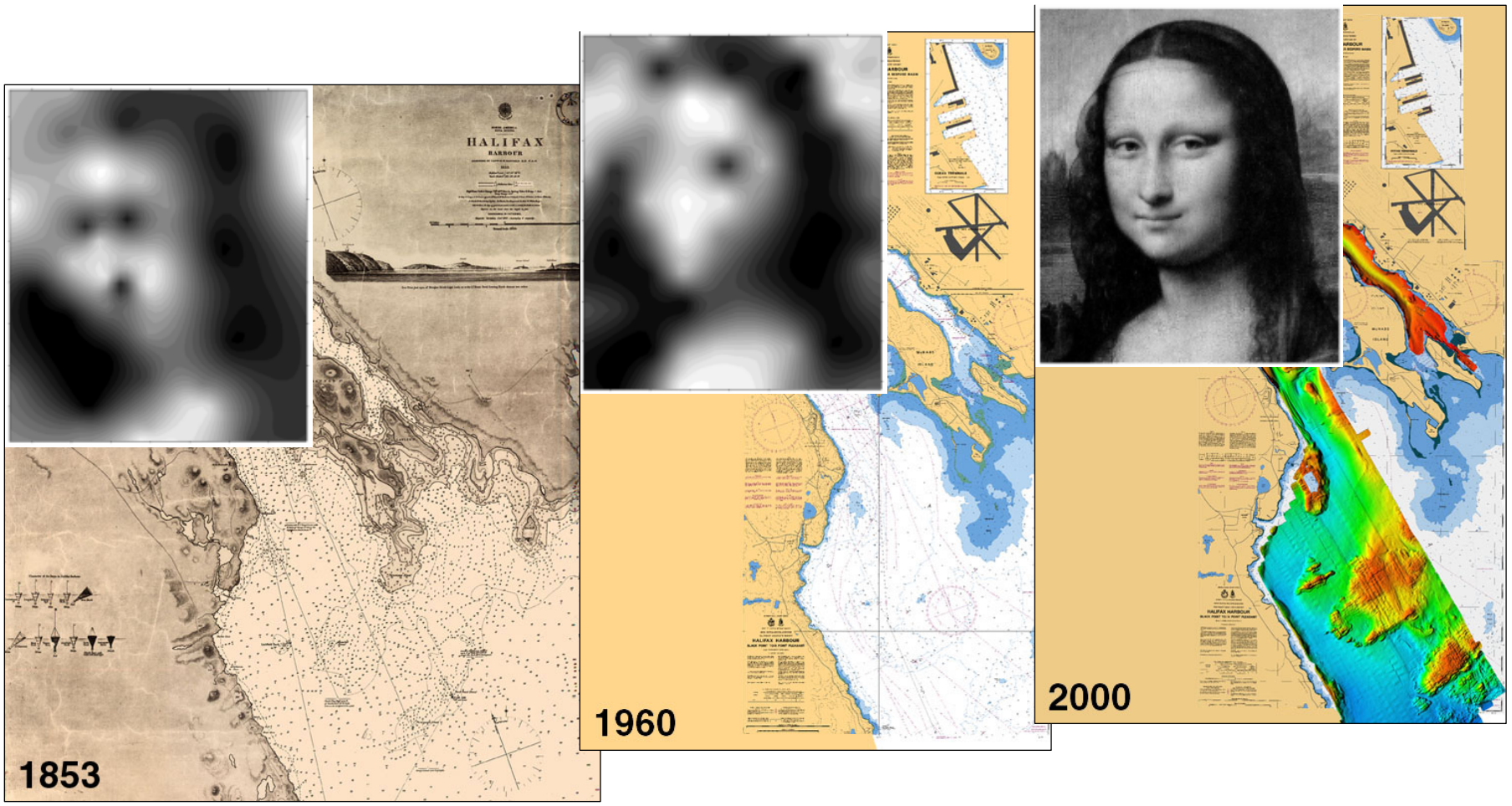


Community/Seascape Biodiversity

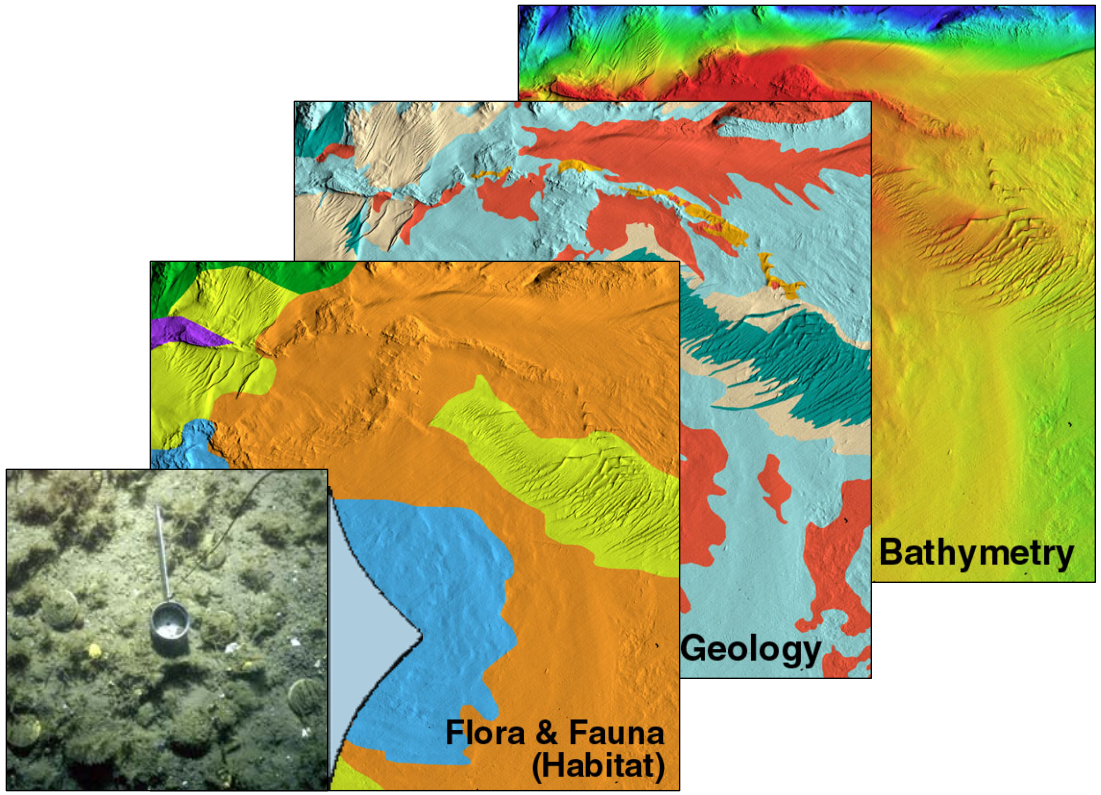
Empirical approach

The Multibeam Sonar Revolution

"Aerial photography" of the sea floor



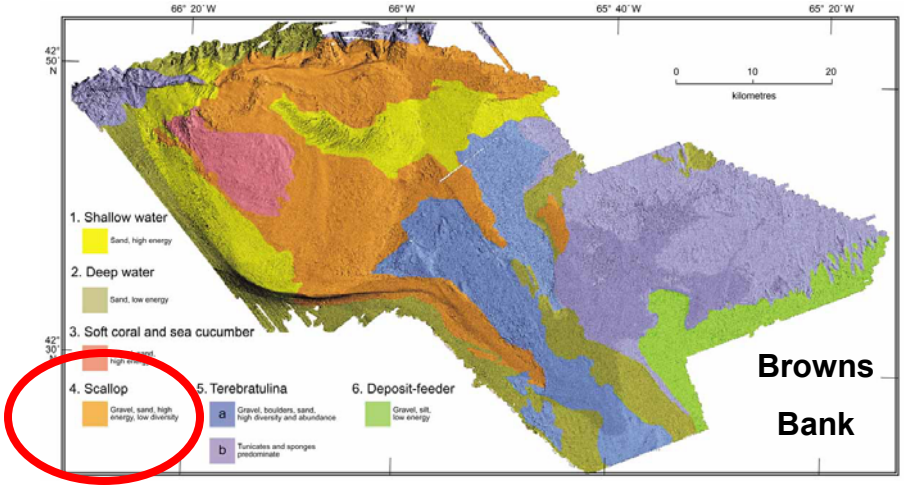
Ocean Mapping: Browns Bank

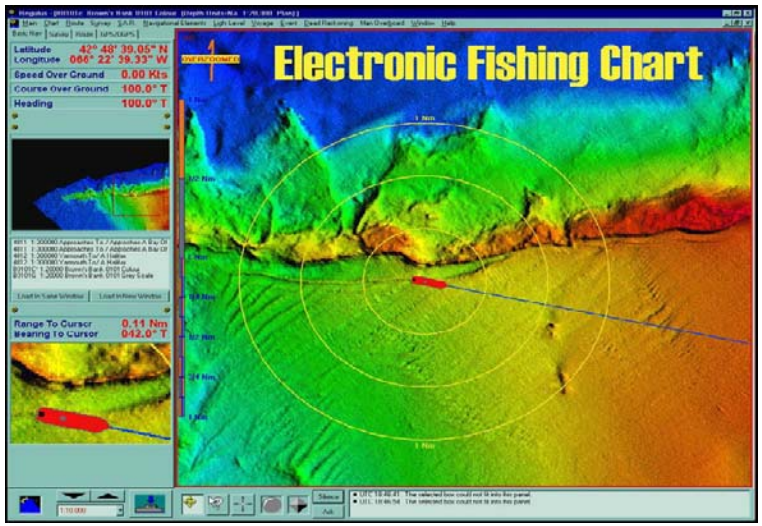


- **Bathymetry: colour-coded, sun- illuminated relief**
- **Geology: surficial sediment type derived from traditional geoscience ground truth surveys**
- **Habitat: statistically-derived communities of benthic species**
- **Sea floor photography: benthic habitat**

"Foundation maps and data sets to deliver Integrated Oceans Management"

Benefits: Living Resources



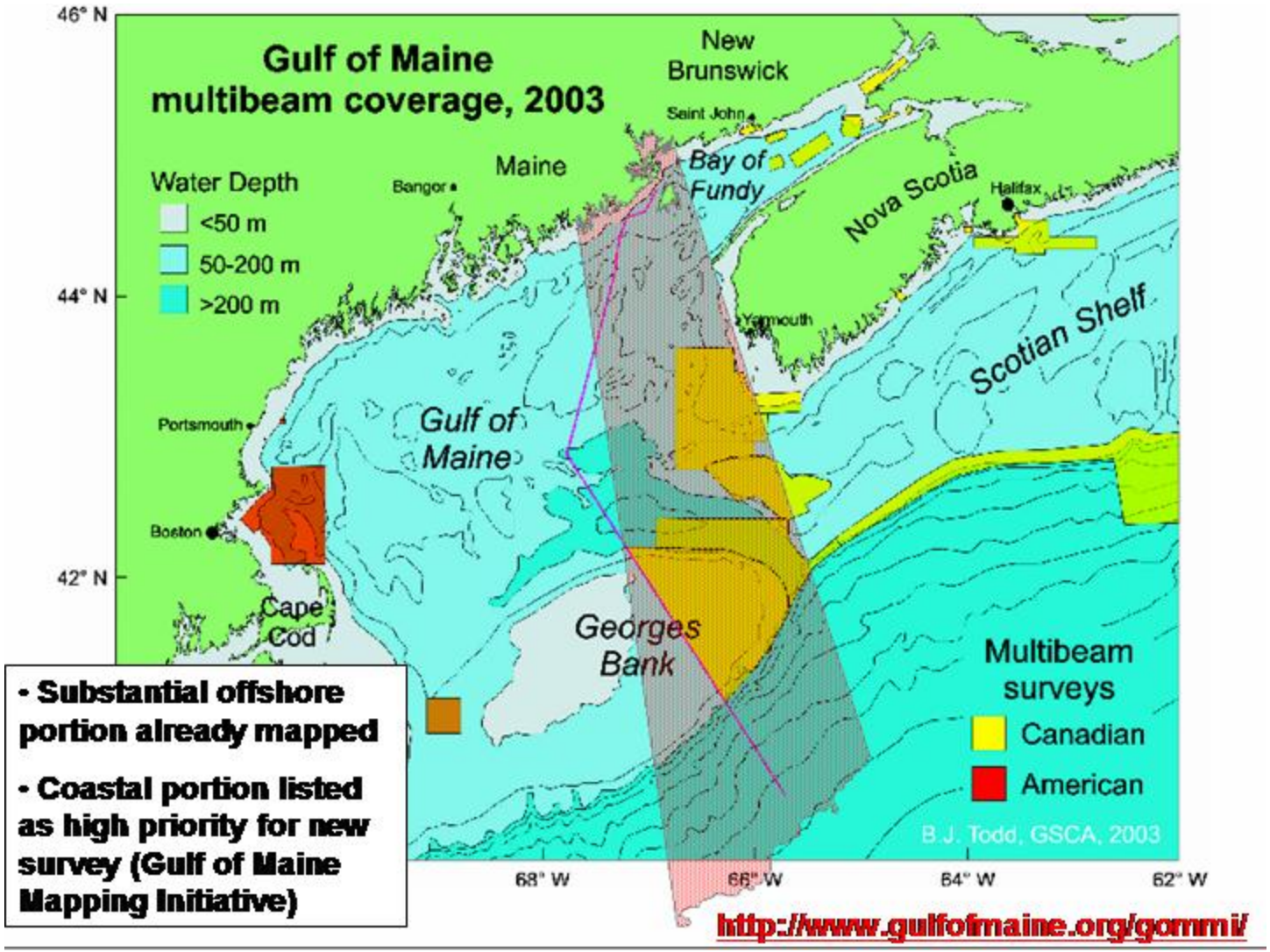


- Commercial scallop fishery
  - electronic fishing charts
  - fishing time reduced 75%
  - self-imposed management practices
  - reduced environmental impact
  - preservation of other commercial habitats
- Fisheries management
  - stock assessment & management practice
  - prerequisite for “sustainable harvest plans” in quota fisheries
- Conservation
  - foundation knowledge base for creation of MPAs

Development of Indicators & Reference Points for Management

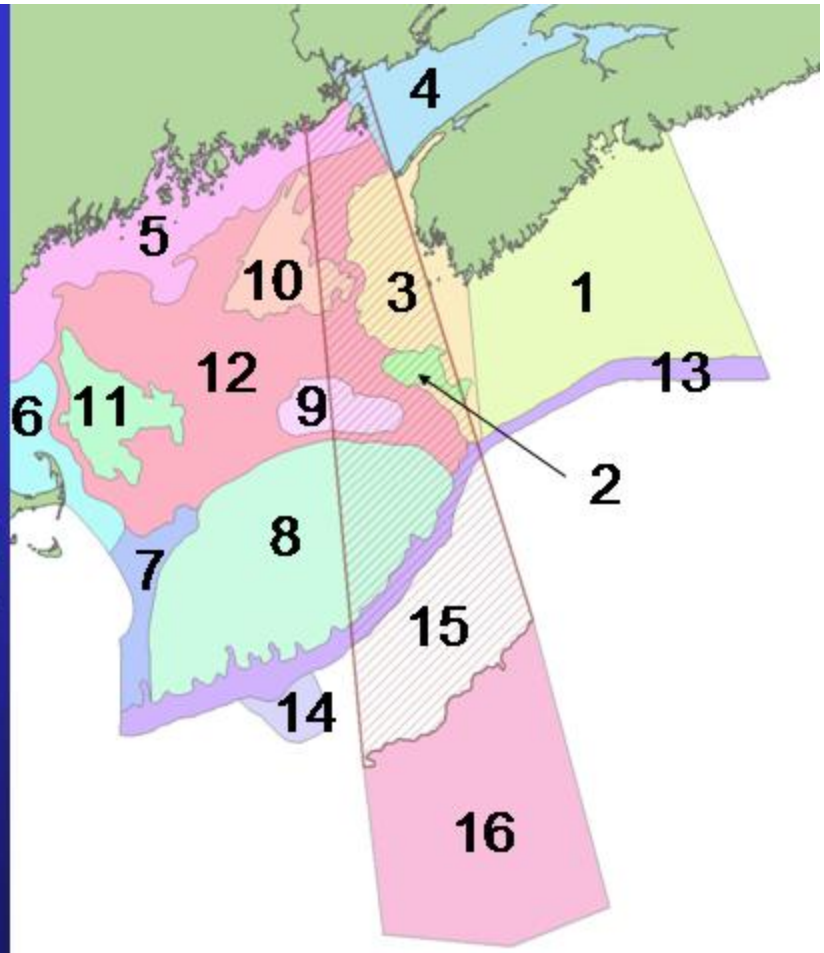
- Establishment of indicators & reference points for benthic communities
- Indicators relatively easy to define (e.g. area of disturbance of each community / seascape type)
- Reference points a challenge (e.g. % allowable disturbance)


Gulf of Maine Biodiversity
Discovery Corridor
S/B


Gulf of Maine
multibeam coverage, 2003
New
Brunswick
Saint John
Maine
Bangor
Bay of
Fundy
Nova Scotia
Halifax
Water Depth
<50 m
50-200 m
>200 m
46° N
44° N
42° N
Yarmouth
Scotian Shelf
Gulf of
Maine
Portsmouth
Boston
Cape
Cod
Georges
Bank
Multibeam
surveys
Canadian
American
B.J. Todd, GSCA, 2003
68° W
66° W
64° W
62° W
• Substantial offshore portion already mapped
• Coastal portion listed as high priority for new survey (Gulf of Maine Mapping Initiative)
http://www.gulfofmaine.org/gomm i/

Physiographic regions

- 9 of 14 previously-defined regions for Census of Marine Life Program* are intercepted
- Coverage varies 10 - 95% of specific region areas
- Two prospective regions (continental rise and abyssal plain) added



*M. Jakobsson and L. Incze:
http://www.usm.maine.edu/gulfofmaine-census/Docs/Research/Posters.htm

CoML Research Agenda

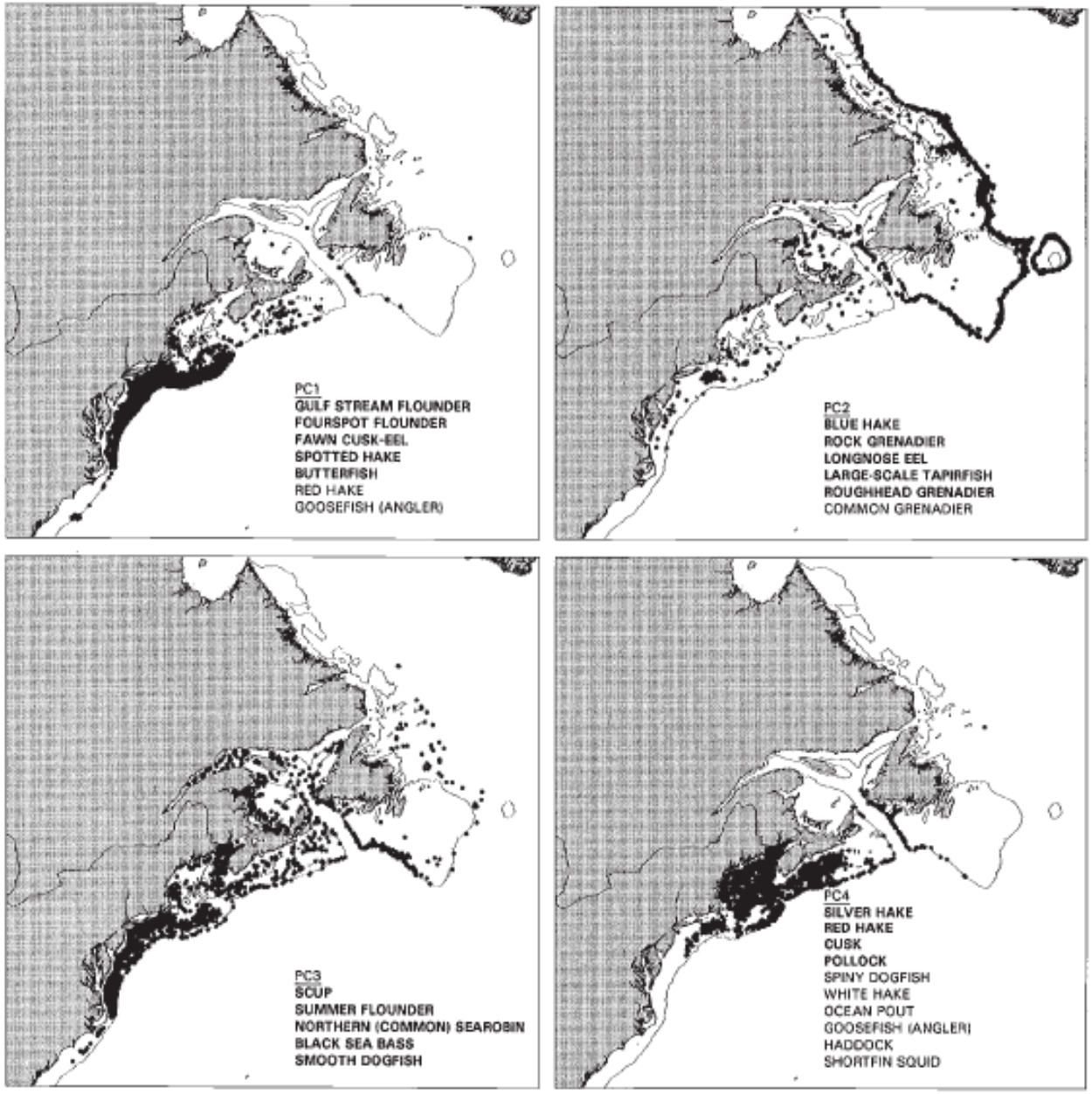
Biodiversity Research

at

Species Level

Can fisheries management & industry respond to large scale species distributional changes?

- Investigate biogeographic characteristics of fish/invertebrate species& how these respond to circulation/mixing
  - Use of OBIS project of CoML

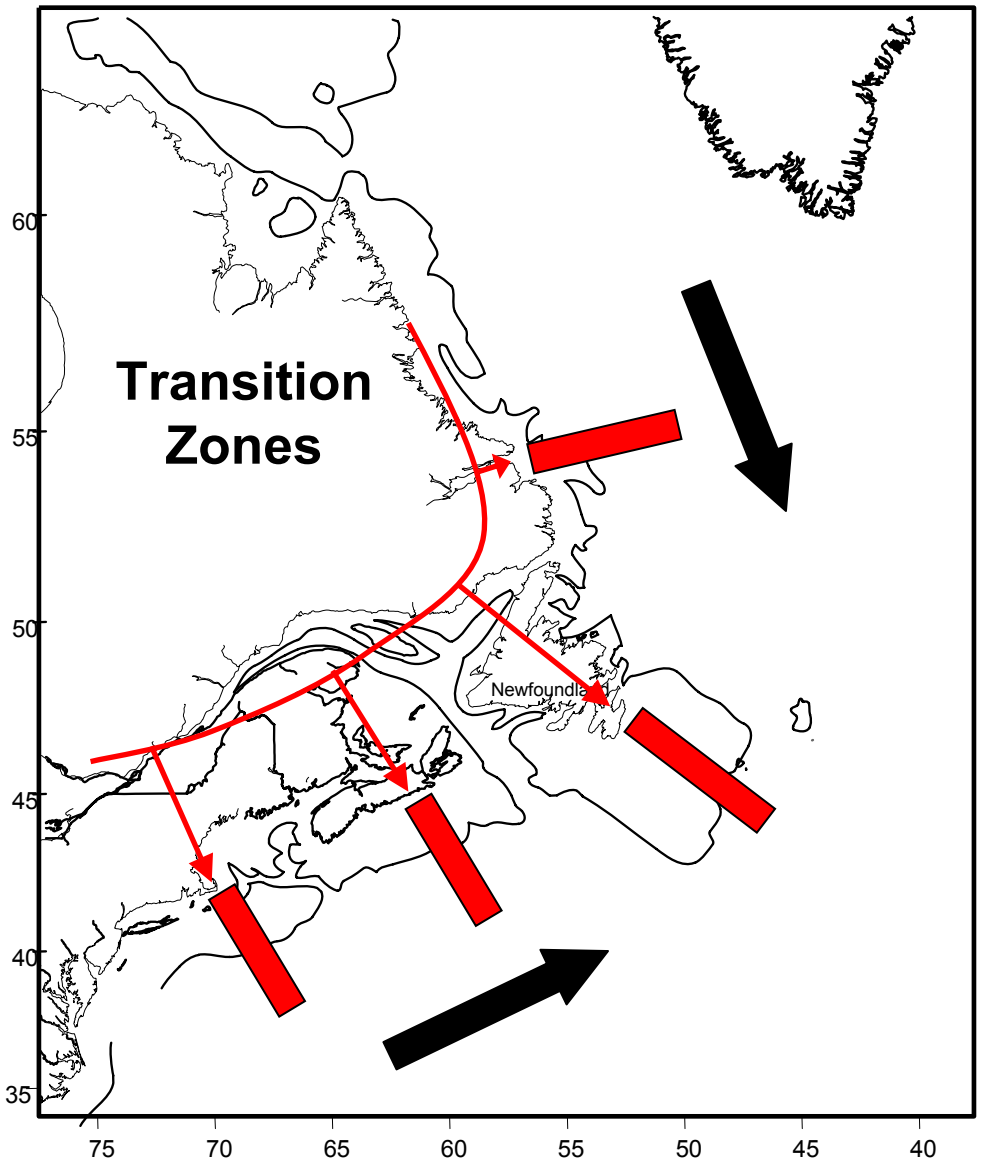


Mahon et. al. 1998

Species Scale Distributions

Identified transitions in bottom communities consistent with circulation & mixing patterns

Movement in transition zones in response to North Atlantic Oscillation (NAO)

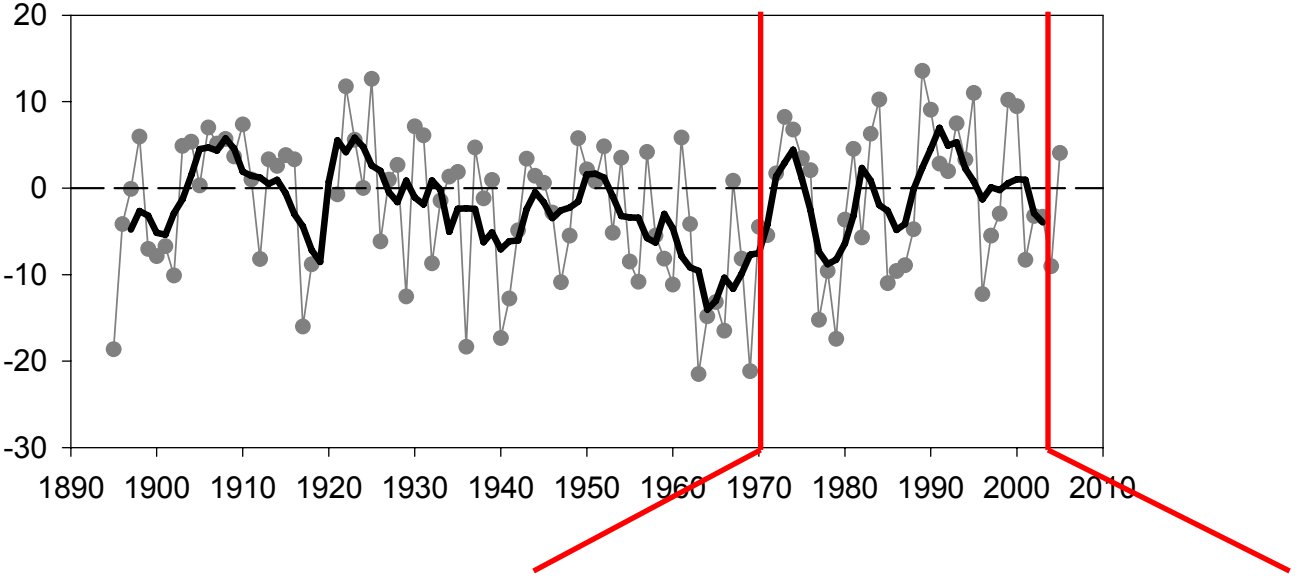


When NAO Positive

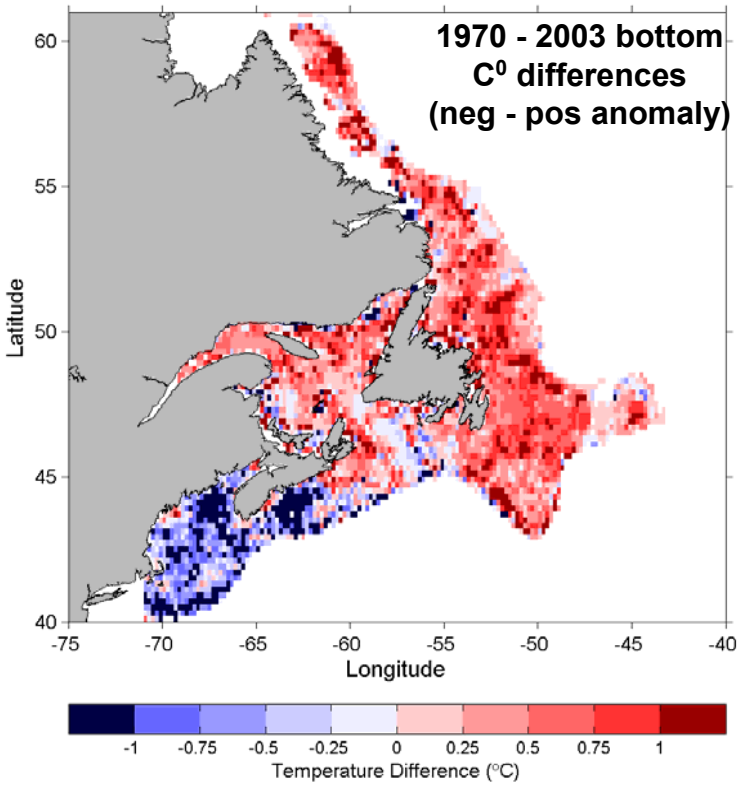
Tendency for Northern Transition Zone to move South
&
Southern Transition Zones to move North

Are these patterns Predictable?

NAO Winter Anomaly

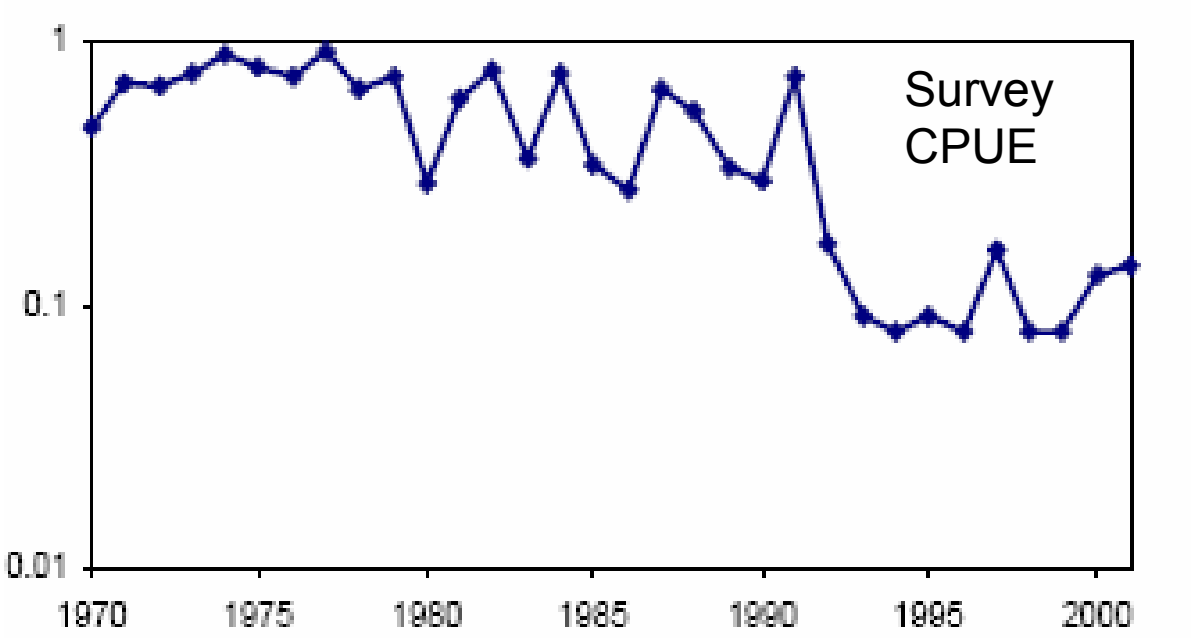


- Linkage of Scotian Shelf with larger North Atlantic atmospheric system
  - Different response to NAO north & south of Halifax
- Periodic? Predictable?



How should species-at-risk be monitored?

- Investigate whether bottom trawl surveys provide reliable indicators of abundance
  - Cusk hard to sample but show dramatic decline in abundance; is this real or due to contraction to preferred habitat?

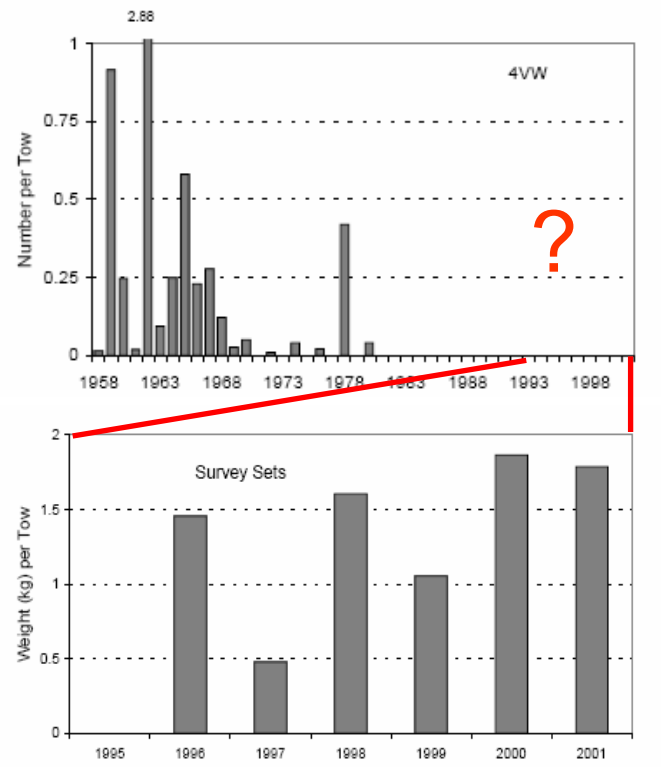


Issues with other species (e.g. Barndoor Skate)

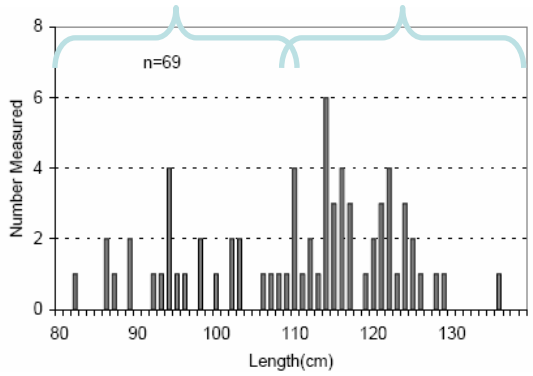
Barndoor Skate & Surveys
Size is Important

Trawl Survey

Longline Survey



Immature Skate **Mature Skate**



Longline Survey samples all size groups
Trawl Survey samples predominantly immature skate

<u>Monitoring species at risk requires consistent time series of Spawners</u>

CoML Research Agenda

Biodiversity Research

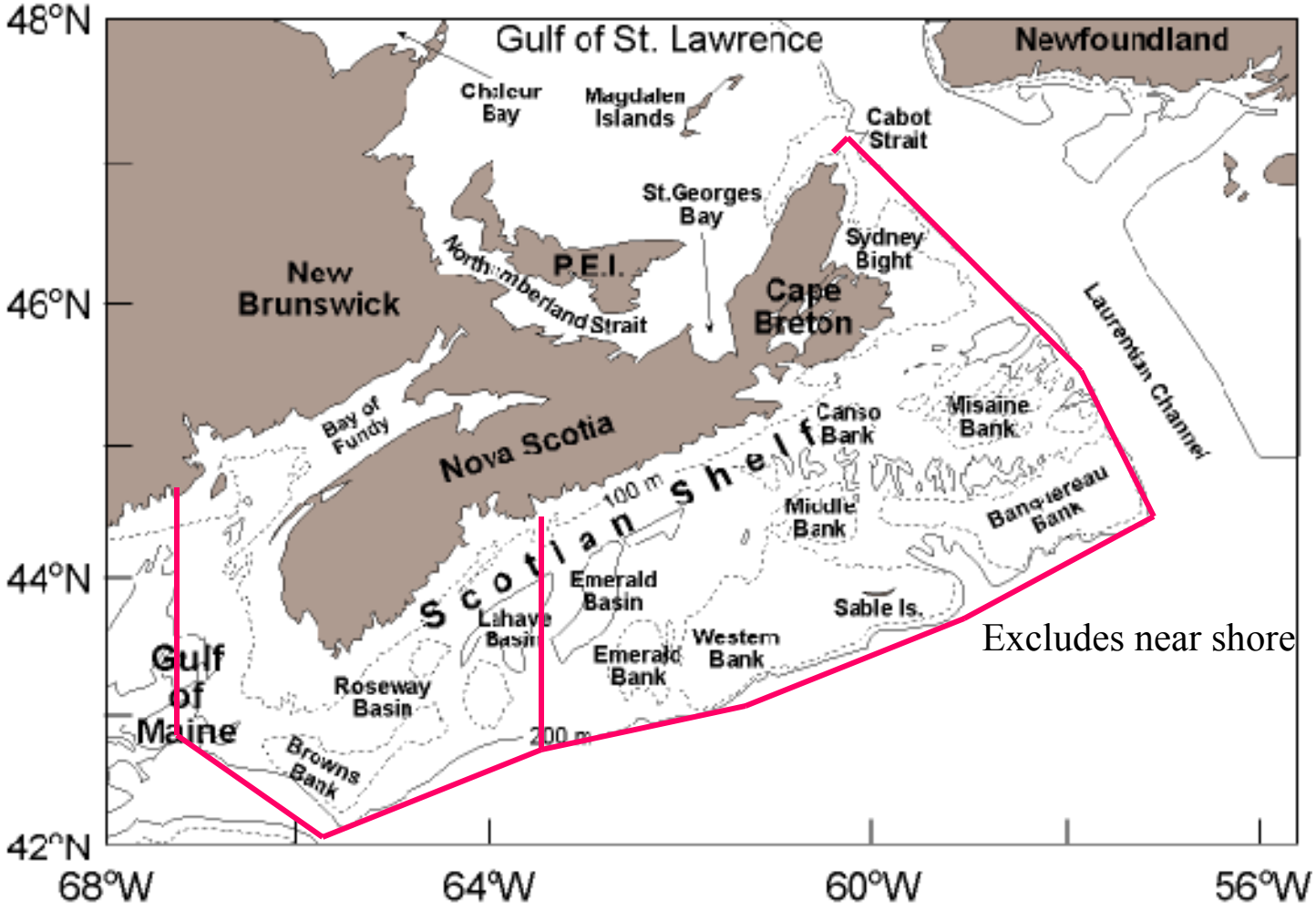
at

Population / Genetic Level

CoML Research Agenda

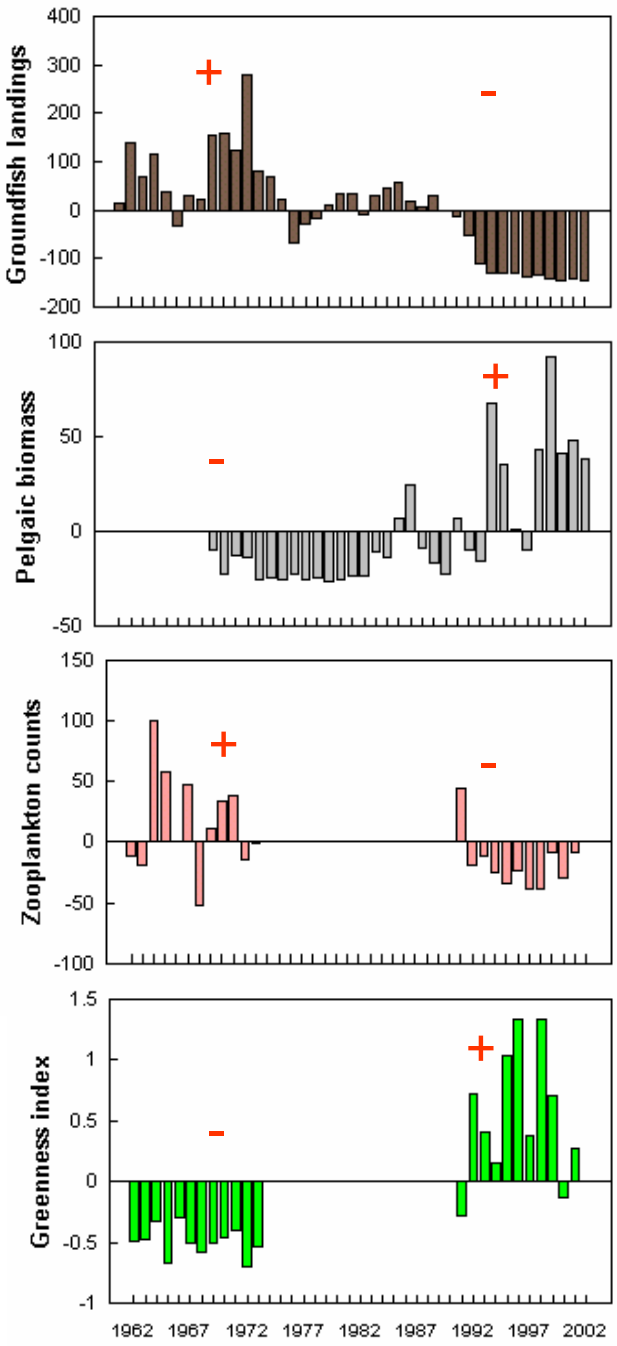
Causality & Cumulative Effects

Understanding role of biodiversity in functioning of marine ecosystems


48°N
46°N
44°N
42°N
68°W
64°W
60°W
56°W
Gulf of St. Lawrence
Newfoundland
Chaleur Bay
Magdalen Islands
Cabot Strait
St.Georges Bay
Sydney Bight
New Brunswick
P.E.I.
Northumberland Strait
Cape Breton
Laurentian Channel
Bay of Fundy
Nova Scotia
Canso Bank
Misaine Bank
Scotian shelf
100 m
Middle Bank
Banquereau Bank
Emerald Basin
Sable Is.
Lahave Basin
Western Bank
Emerald Bank
Gulf of Maine
Roseway Basin
200 m
Browns Bank
Excludes near shore

What are management implications of systematic removal of large fish on ecosystem functioning?

- ESS ecosystem regulation
  - bottom - up or top - down?
  - Frank et al (2003) suggests top - down

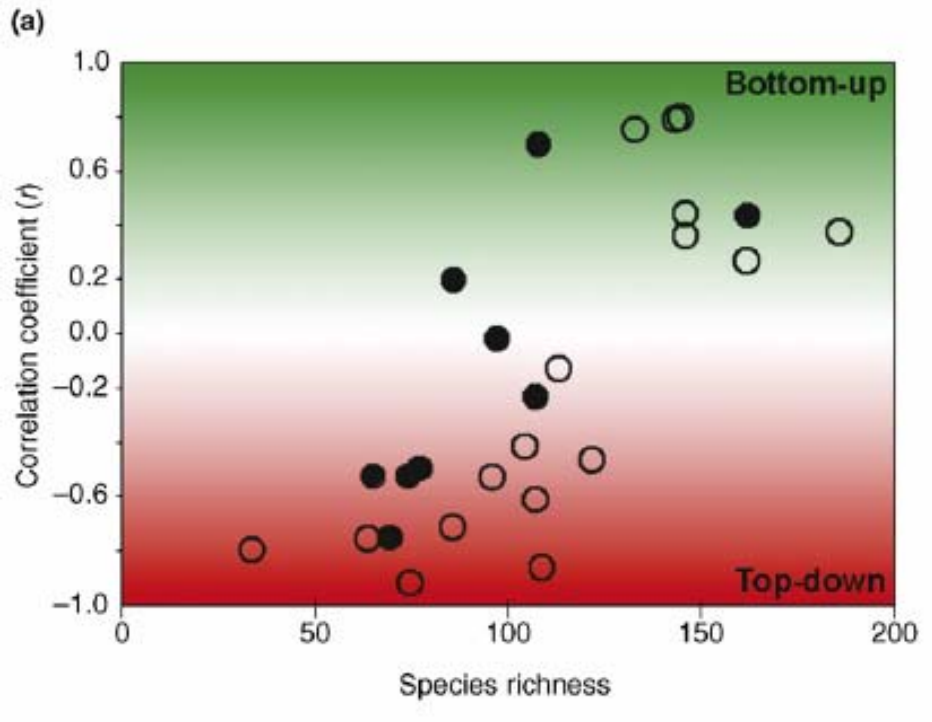


Western Scotian Shelf
Evidence supports bottom-up control

- Food chain structure not changed
  - functional redundancy: dogfish approximate equivalent to cod in trophic interaction terms
  - small pelagics held in check unlike ESS
    - ESS - no functional equivalent to cod in sufficient abundance (elasmobranch species – 7%, on average, of total groundfish biomass)
    - Compositional changes in WSS fish community much less than on ESS suggesting former is more stable

Biodiversity key to Ecosystem Resilience to Disturbance

Species Richness & Ecosystem Control



Overfishing

- **Reduces species richness**
- **May cause flip from bottom – up to top – down control (Frank et al., 2007)**

Need to develop quantitative understanding of relationships amongst exploitation & species richness & ocean climate

Assessment Report of the Future

Suite of Conceptual & Operational Objectives defines EAM in Planning Area

Overarching Conceptual Objective	Planning Area Conceptual Objective	Planning Area Operational Objective	Fisheries Sector OO	Groundfish Fishery OO	Oil & Gas Sector OO	Transport Sector OO	Defense Sector OO
	Diversity of Benthic Communities					N/A	N/A
Community Biodiversity	Diversity of Fragile Coral Community		N/A			N/A	
	High Diversity Gully Benthic Community		N/A			N/A	
	Overall Species Diversity		N/A	N/A	N/A		N/A
Species Biodiversity	SAR Diversity		N/A		N/A	N/A	N/A
			N/A		N/A		N/A
Population Biodiversity	Genetic Diversity		N/A		N/A	N/A	N/A
Primary Productivity	Productivity at base of food chain		N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A
	Productivity of Forage Species			N/A	N/A	N/A	N/A
Trophic Structure	Trophic Level Productivity		N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A
	Energy transfer			N/A	N/A	N/A	N/A
	Growth Productivity		N/A		N/A	N/A	N/A
Population Generation Time	Recruitment Productivity		N/A		N/A	N/A	N/A
			N/A	N/A		N/A	N/A
	Sediment Quality		N/A	N/A		N/A	N/A
Physical Features			N/A	N/A		N/A	N/A
	Sound Environment		N/A	N/A		N/A	
	Chemical Environment		N/A	N/A		N/A	N/A
Chemical Features			N/A	N/A		N/A	N/A
	Physiological Processes		N/A	N/A		N/A	N/A
			N/A	N/A		N/A	N/A

Colour indicates Performance Of Operational Objective

Green:	**Good**
Yellow:	**Caution**
Red:	**Poor**

Conclusions

Canadian CoML is making

critical contributions

to implementation of biodiversity objectives of EAM